

LINE CHARGE CONNECTOR
Statement of Government Interest

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Cross Reference to Related Application

This is a continuation in part of copending U. S. patent applications entitled "Line Charge Insensitive Munition Warhead" by Felipe Garcia et al., U.S. Patent and Trademark Office Serial No. ^{08/944049} ~~(NC 78,448)~~, filed ^{9/12/97} and "Reliable and Effective Line Charge System" by Felipe Garcia et al., U.S. Patent and Trademark Office Serial No. ^{09/012932} ~~(NC 78,433)~~, filed ¹⁻²⁴⁻⁹⁸ and incorporates all references and information thereof by reference herein.

Background of the Invention

This invention relates to deployable munitions. In particular, this invention relates to line charges for clearing mines and obstacles that are made up from explosive segments joined together by connectors which withstand severe deployment forces and position detonation components for each segment to reliably deploy and detonate the line charges.

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1 Anti-personnel obstacles and/or mines have been cleared
2 from narrow passageways or lanes using a number of different
3 explosive devices. Among these devices, however, the above
4 referenced line charge system has proven to be one of the most
5 effective. This line charge has a preassembled series of
6 warheads and a common detonating cord extends through them. A
7 rocket motor pulls the line charge across a designated area,
8 the cord is detonated by a fuze, and the exploding warheads
9 clear the obstacles and mines from a lane that extends the
10 length of the line charge. Notwithstanding the effectiveness
11 of this line charge, the firing teams which deploy it and other
12 obstacle breaching systems have found that sometimes obstacles
13 and/or mines must be cleared from lanes that are longer than
14 the lengths of the preassembled line charges. Heretofore,
15 there has been no effective means to rapidly and reliably
16 connect together portable explosive sections of warheads or
17 other explosives to form differently sized line charges for
18 clearing obstacles and mines over longer distances. Connecting
19 some existing breaching systems together has been a laborious
20 task requiring tools to perform necessary modifications. No
21 connector existed to quickly connect two or more parts of a
22 line charge together in an economical and rapid manner while
23 maintaining structural integrity during deployment and

1 preserving critical tolerances needed to transfer explosive
2 detonation between parts. Most contemporary line charges are
3 built at the factory as complete units without any means to
4 connect units together in longer line charges.

5 Thus, in accordance with this inventive concept, a need
6 has been recognized in the state of the art for connectors that
7 interconnect explosive segments of line charges rapidly and
8 reliably in the field to form differently sized line charges
9 for clearing obstacles and mines over different distances.

10 Summary of the Invention

11 The invention is directed for providing a connector for
12 segments. A male portion of the connector has coupling
13 elements to connect to strength members of one segment and an
14 axial bore to secure and position one end of detonating cord
15 that extends from the segment. A female portion of the
16 connector has coupling elements to connect to strength members
17 of another segment and an axial bore to secure and position one
18 end of another detonating cord extending from the other
19 segment. A spring clip extends through the female portion and
20 engages part of the male portion which is sized to be inserted
21 in the female portion and engaged by the spring clip. This
22 places the ends of the detonating cords adjacent one another
23 and assures transfer of detonation between them.

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1 An object of the invention is to provide a connector to
2 join explosive segments of line charges for clearing lanes
3 through mines and obstacles.

4 Another object of the invention is to provide a line
5 charge having connectors joining explosive segments to allow
6 for the modification of the demolition capability of the line
7 charge as needed.

8 Another object of the invention is to provide rapid and
9 reliable connections of portable explosive segments by a firing
10 team to clear lanes through differently sized areas.

11 Another object is to provide a connector between explosive
12 segments of a line charge that withstands deployment loads
13 while assuring detonation of the explosive segments.

14 Another object is to provide means of connecting two or
15 more explosive segments in the field without tools.

16 Another object of the invention is to provide a connector
17 that assures transfer of detonation between detonation cords
18 and detonation boosters on detonating cords.

19 Another object of the invention is to provide a connector
20 that axially and linearly aligns explosive components that
21 transfer detonation among explosive segments of a line charge.

22 Another object is to provide a connector that positively
23 locks to ensure structural integrity of line charges.

1 Another object of the invention is to provide lightweight,
2 economical, and rapidly coupled connectors between explosive
3 segments of a line charge that maintain structural integrity
4 during deployment and transfer detonation between the
5 detonating cords and boosters of each explosive segment.

6 These and other objects of the invention will become more
7 readily apparent from the ensuing specification when taken in
8 conjunction with the appended claims.

9 Brief Description of the Drawings

10 Figure 1 is a schematic representation of a line charge
11 having a plurality of explosive segments joined by connectors
12 as it is being deployed across obstacles and mines to clear a
13 safe lane.

14 Figure 2 isometrically depicts a connector having
15 separated male and female portions, and the spring clip removed
16 from the female portion.

17 Figure 3 is a longitudinal cross-sectional view of the
18 male and female portions taken generally along lines 3-3 in
19 Figure 2 but showing the male and female portions connected
20 together by the spring clip.

21 Figure 4 is an enlarged cross-sectional view taken along
22 lines 4-4 in Figure 3 showing spring clip on large and small

clip rails in the female portion engaging the groove of the male portion.

Description of the Preferred Embodiment

Referring to Figure 1 of the drawings, line charge 10 is schematically depicted being deployed by an interconnected rocket motor 11. Motor 11 pulls line charge 10 across an area laden with mines and other obstacles that block or interfere with free passage through it. Detonation of the deployed line charge 10 clears a safe and uncluttered passageway.

Line charge 10 includes a plurality of elongate explosive segments 15 coupled together by a plurality of interposed connectors 20. Only three explosive segments 15 are shown coupled together by two connectors 20; it is understood that more or less could be joined by an appropriate number of connectors 20 to clear longer or shorter paths as needed.

Each explosive segment 15 contains a number of serially arranged explosive charges or warheads 15' that are each appropriately connected to elongate flexible strength members 16 and 17 that extend from one end to the other end. Only a few explosive charges or warheads 15' are shown in the leftmost explosive segment 15 in Figure 1 to avoid unnecessary distraction from this invention; it is understood that each explosive segment 15 contains as many such charges 15' as are

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1 needed to successfully complete different missions as they
2 arise. The explosive charges are selected from a wide variety
3 of explosive materials and are appropriately sized and spaced
4 apart to accomplish the task at hand. Strength members 16 and
5 17 are suitably sized natural or manmade flexible lines or
6 cables, e. g., nylon or metal strands, to provide support
7 during the severe loading encountered as line charge 10 is
8 deployed.

9 The explosives of each explosive segment 15 are detonated
10 by detonating cord 18 that extends the length of each explosive
11 segment 15. Detonating cord 18 is, preferably, routed through
12 openings in each explosive charge contained in each explosive
13 segment 15. Consequently, when each detonating cord 18 is
14 detonated, all the explosive charges in all explosive segments
15 are exploded virtually simultaneously.

16 Clearing a lane through an area requires that line charge
17 10 is emplaced to lie across the area. Then, it is detonated.
18 A proven method of accurately emplacing line charge 10 relies
19 on coupling rocket motor 11 to one end and a drag or an
20 anchoring device 50 to the other end. Anchoring device 50 may
21 be a fixed solid structure at the near side of the area, a
22 drogue chute, or a combination of the two, for example. Rocket
23 motor 11 is aimed to cross the obstructed area. When it is

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1 fired, it accelerates rapidly and pulls line charge 10 along
2 with it. Anchoring device 50 may stop line charge 10 violently
3 from going further. During the launching and stopping phases,
4 connectors 20 hold strength members 16 and 17 of explosive
5 segments 15 together. Initiation of detonation in detonation
6 cord¹⁸ and detonation cord boosters 18' by fuze 19 detonates line
7 charge 10 throughout to break up, blow-out-of-the-way, and/or
8 detonate the obstacles/mines.

9 Referring to Figure 2, connector 20, fabricated in
10 accordance with this invention, gives the firing team that
11 deploys line charge 10 the capability to change it in the field
12 for different breaching operations. Explosive segments 15 can
13 be carried by the firing team to the area to be breached. All
14 that the team needs to do is merely add or take away explosive
15 segments 15 by connecting the mating portions of male and
16 female portions 25 and 30 of connector 20 via spring clip 40.

17 Male portion 25 is secured to end portions 16a and 17a of
18 strength members 16 and 17 of explosive segment 15 via a pair
19 of metal or synthetic ring-shaped clamps 26 that may have
20 rounded or flat, strap-like cross-sectional shapes. Clamps 26
21 may be rigid, but more likely are adjustable with mutually
22 engaging sections tightened and/or otherwise secured to couple
23 end portions 16a and 17a of strength members 16 and 17 to male

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1 portion 25. End portions 16a and 17a are wrapped about clamps
2 26. The wrapped clamps 26 are slid along outer surface 25a of
3 male portion 25 toward annular rim 27 which radially extends
4 from male portion 25. Clamps 26 clamp end portions 16a and 17a
5 on knurled surfaces 25b on outer surface 25a of male portion
6 25. In addition, if clamps 26 are positioned next to annular
7 rim 27, clamps 26 also clamp end portions 16a and 17a against
8 annular rim 27. This mechanical cooperation secures male
9 portion 25 to strength members 16 and 17 of one explosive
10 segment 15.

11 Female portion 30 is secured to end portions 16a' and 17a'
12 of strength members 16' and 17' of explosive segment 15' via a
13 pair of metal or synthetic clamps 31 that may have rounded or
14 flat, strap-like cross-sectional shapes. Clamps 31 may be
15 rigid, but more likely are adjustable with mutually engaging
16 sections. End portions 16a' and 17a' are wrapped about clamps
17 31. The wrapped clamps 31 are slid along outer surface 30a of
18 female portion 30 toward annular rim 32 which radially extends
19 from female portion 30. Clamps 31 clamp end portions 16a' and
20 17a' on knurled surfaces 30b on outer surface 30a of female
21 portion 30. In addition, if clamps 31 are positioned next to
22 annular rim 32, clamps 31 also clamp end portions 16a' and 17a'
23 against annular rim 32. This mechanical cooperation secures

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a 1 female portion 30 to strength members 16' and 17' of another
2 explosive segment 15. No ^{tools} ~~tools~~ are needed to connect the male
3 and female portions 25 and 30 together.

4 If, however, the mating portions of connector 20 have not
5 been previously mounted on ends of strength members 16 and 17,
6 this mounting can be done in the field by the firing team with
7 small hand tools. The firing team can quickly attach male and
8 female portions 25 and 30 to opposite ends of strength members
9 16 and 17 by merely sliding clamps 26 and 31 off of male and
10 female portions 25 and 30, looping end portions 16a and 17a and
11 16a' and 17a' of strength members 16 and 17 through rings 26
12 and 31, respectively. Next, clamps 26 and wrapped ends 16a and
13 17a are respectively slid along surfaces 25a and 25b to rim 27,
14 and clamps 31 and wrapped ends 16a' and 17a' are slid along
15 surfaces 30a and 30b to rim 32.

16 Detonating cord 18 is secured into bores 28 and 33 of male
17 and female portions 25 and 30 in the factory using epoxy 28"
18 and 35' in bores 28' and 35. Detonating cord 18 is secured
19 into bores 28 and 33 of male and female portions 25 and 30 in
20 the field by frictionally fitting and engaging detonating cord
a 21 18 in bores 28 and ³³ ~~35~~, see Figure 3. Bores 28 and 33 are sized
22 to frictionally engage the lateral surfaces of opposite ends
23 18a and 18b of detonating cords 18 or detonating cord boosters

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1 18' attached to detonating cords 18 of each explosive segment
2 15. The frictional engagement is such as to hold opposite ends
3 18a and 18b in close proximity when male and female portions 25
4 and 30 are coupled together by spring clip 40. This close
5 proximity of ends 18a and 18b is within predetermined tolerance
6 limits required to assure transfer of detonation between
7 adjacent explosive segments. These tolerances are maintained
8 by precisely engaging and locating end portions 18a and 18b of
9 the detonating cords by the critically sized bores 28 and 33 in
10 male and female portions 25 and 30. Consequently, when
11 detonation of the line charge is initiated by detonating the
12 detonating cord in one explosive segment, detonation of all the
13 interconnected explosive segments will occur virtually
14 simultaneously. Note that frictional connection in the field
15 is not as reliable to maintain critical tolerances as the epoxy
16 method performed at the factory.

17 Details of male and female portions 25 and 30 are shown in
18 Figures 3 and 4. Male and female portions 25 and 30 that have
19 been previously mounted on opposite ends of strength members
20 16, 17, 16', and 17' of two explosive segments 15 are easily
21 connected together by spring biased legs 40a of spring clips
22 40. Legs 40a interlock annular groove 29 machined in elongate

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1 part 25' of male portion 25. Interlocking legs 40a in groove
2 29 secure male and female portions 25 and 30 together.

3 Spring clip 40 is releasably mounted in female portion 30
4 during storage and transit. Spring clip 40 is retained on
5 large clip rail 30' and small clip rail 30" to extend through
6 female portion 30. Large and small clip rails 30' and 30" are
7 formed in female portion 30 when parts of it are machined-away
8 to create openings 36. Legs 40a of clip 40 reach through
9 openings 36 and into bore 34 of female portion 30.

10 All that is needed to connect male and female portions 25
11 and 30 together is to insert elongate part 25' of male portion
12 25 into bore 34 of female portion 30. Tapered front section
13 25" spreads legs 40a apart as elongate part 25' of male portion
14 25 is being inserted in bore 34. When legs 40a become radially
15 aligned with portions of annular groove 29 in male portion 25,
16 legs 40a of spring clip 40 snap into annular groove 29 to
17 interlock male portion 25 in female portion 30. This occurs
18 without any tools or unnecessary delay.

19 Female portion 30 is made of aluminum alloy 6061-T651 a
20 lightweight material that is strong enough to sustain the
21 deployment loads associated with deployment by rocket motor 11.
22 Other suitable lightweight and strong materials could be used,
23 e. g., nylon, space-age plastics, combinations of such

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1 materials, etc. Female portion 30 is anodized to limit
2 corrosion potential in moist salt environments and to create a
3 low friction sliding surface which eases insertion of elongate
4 part 25' of male portion 25 into bore 34 of female portion 30.
5 Bore 34 is appropriately sized to allow male portion 25 to
6 slide into and fit inside of it and is aligned with the other
7 bores of female portion 30. Female portion 30 has a third bore
8 35 for passing end portion 18b of detonating cord 18 through it
9 and feeding it to aligned bore 33. Bore 33 is narrower than
10 bore 34 to secure and position end portion 18b of detonation
11 cord 18.

12 Male portion 25 also is made of aluminum alloy 6061-T651
13 in order to sustain the deployment loads associated with rocket
14 deployment. Other suitable lightweight and strong materials
15 could be used, e. g., nylon, space-age plastics, combinations
16 of such materials, etc. Male portion 25 is also anodized to
17 limit corrosion potential in moist salt environments and to
18 create a low friction sliding surface to ease insertion of
19 elongate part 25' into bore 34 of female portion 30. Tapered
20 front section 25" of male portion 25 is cone-shaped to
21 facilitate alignment and ease of insertion into bore 34 of
22 female portion 30. As mentioned above, annular groove 29 is
23 provided adjacent tapered front section 25" of male portion 25

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1 to receive spring clip 40 for interlocking and holding male and
2 female portions 25 and 30 together. Bore 28 of male portion 25
3 is appropriately sized to align and position end portions 18a
4 and 18b of detonating cords ¹⁸ 18 in male and female portions 25
5 and 30 ~~18~~ to assure uninterrupted, continuous detonation
6 between adjacent explosive segments 15 of line charge 10.
7 Optionally, to enhance reliability of detonation between
8 adjacent explosive segments 15, detonating boosters 18' may be
9 crimped or otherwise suitably attached to detonating cords 18
10 in male portion 25 and female portion 30. When detonating
11 boosters 18' are included on detonating cords 18 in male and
12 female portions 25 and 30, ends 18a and 18b will be the ends of
13 detonating boosters 18'.

14 Male portion 25 has a second bore 28' that may be filled
15 with a suitable bonding agent 28", such as epoxy, to secure
16 detonating cord 18 after it passes through opening 27" of plug
17 27'. This filling with a suitable bonding agent will occur
18 when male portion 25 is assembled and attached to explosive
19 segment 15 at the factory. When connectors 20 might have to be
20 secured to explosive segments 15 in the field, bonding agent
21 28" may have to be dispensed with. End portion 18a of
22 detonating cord 18 is additionally secured in male portion 25
23 by being frictionally engaged in aligned bore 28.

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1 Third bore 35 of female portion 30 may be filled with a
2 suitable bonding agent 35', such as epoxy, to secure detonating
3 cord 18 after it passes through opening 32" of plug 32'. This
4 filling with a suitable bonding agent will occur when female
5 portion 30 is assembled and attached to explosive segment 15 at
6 the factory. When connectors 20 might have to be secured to
7 explosive segments 15 in the field, bonding agent 35' may have
8 to be dispensed with. End portion 18b of detonating cord 18 is
9 additionally secured in female portion 30 by being frictionally
10 engaged in aligned bore 33.

11 When male portion 25 is fitted in female portion 30 and
12 spring clip 40 engages groove 29, end portions 18a and 18b of
13 detonation cords 18 and detonating boosters 18' of adjacent
14 explosive segments 15 are aligned and sufficiently in contact
15 or close proximity with each other to assure mutual detonation.
16 This proximity between end portions throughout line charge 10
17 will assure detonation of all explosive segments 15.

18 The advantages of connector 20 in line charges 10 over
19 previous explosive systems and methods of deployment are
20 numerous. Connector 20 allows for the rapid connection of two
21 explosive segments 15 by the firing team in the field to allow
22 several explosive segments 15 to be carried separately, so that
23 the firing team can carry the total payload in containers

1 carried by individual soldiers. Connector 20 provides a light
2 weight, economical, and rapid connection method for connecting
3 together multiple line charge segments without the need for
4 tools. Connector 20 maintains critical tolerances between
5 detonating cord boosters and detonating cords to assure
6 explosive transfer. Strength members of adjacent segments 15
7 may be attached to the connector in an effective manner.
8 Connector 20 provides axial and linear self alignment of
9 explosive components needed for the transfer of a detonation
10 from one line explosive segment to the next. Connector 20
11 provides a positive lock thereby ensuring line charge
12 structural integrity. Connector 20 also provides for low
13 friction at the sliding interfaces between male and female
14 portions 25 and 30. Additionally, the knurling provided on the
15 exterior surfaces increases the frictional forces that rings 26
16 and 31 and rims 27 and 32 exert when attached to strength
17 members 16 of explosive segments 15 of line charge 10.

18 In the representative embodiment set out herein, only two
19 strength members 16 were shown in each explosive segment 15
20 only for the purpose of an example. Other arrangements and
21 numbers of strength members could be interconnected to
22 connector 20 in accordance with this invention. In addition,
23 this invention not only is capable of coupling explosive

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1 segments together. These segments might be, for example,
2 segments of an aerially deployed life line containing strong
3 lines or hawsers, segments of electrical power cables, or
4 segments of water or POL supply hoses. When connected
5 according to this invention, the joined segmented structure can
6 reach across barriers or other impasses. The connector of this
7 invention can be modified to provide these capabilities and
8 still be within the scope of this inventive concept.

9 Connector 20 joining explosive segments 15 of line charge
10 has been described using an exemplary arrangement of
11 components. This arrangement is not to be construed as
12 limiting, but rather is intended for demonstrating this
13 inventive concept. The disclosed components and their
14 arrangements as disclosed herein all contribute to the novel
15 features of this invention. These novel features assure more
16 reliable and effective deployment of multi capable line charges
17 10 to successfully complete different missions as they arise.
18 It is to be understood that the configuration of the components
19 of connector 20 could be modified to accommodate different
20 applications and still be within the scope of this inventive
21 concept. In addition, different materials could be selected to
22 provide sufficient strength and durability for the task at hand
23 without departing from the scope of this invention. If elastic

1 limits of the strength members or other materials used in the
2 construction of the original embodiment are exceeded during
3 deployment, then alternative materials may be used to account
4 for increased loading rates.

5 Therefore, it is to be understood that, having the
6 teachings of this invention in mind, one skilled in the art to
7 which this invention pertains can select other combinations of
8 materials and arrangements thereof and still be within the
9 scope of this invention. Similarly, the capabilities of the
10 invention that were disclosed herein were selected for
11 demonstration of some salient features of this invention. They
12 are not to be construed to limit the scope of this invention.

13 It should be readily understood that many modifications
14 and variations of the present invention are possible within the
15 purview of the claimed invention. It is to be understood that
16 within the scope of the appended claims the invention may be
17 practiced otherwise than as specifically described.